MONTANA STATE HIGHWAY DEPARTMENT

HIGHWAY PLANNING SURVEY

IN COOPERATION WITH

PUBLIC ROADS ADMINISTRATION

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ECONOMIC ANALYSIS OF THE MALTA-GRASS RANGE SECTION OF FEDERAL AID ROUTE NO. 16

March 1946

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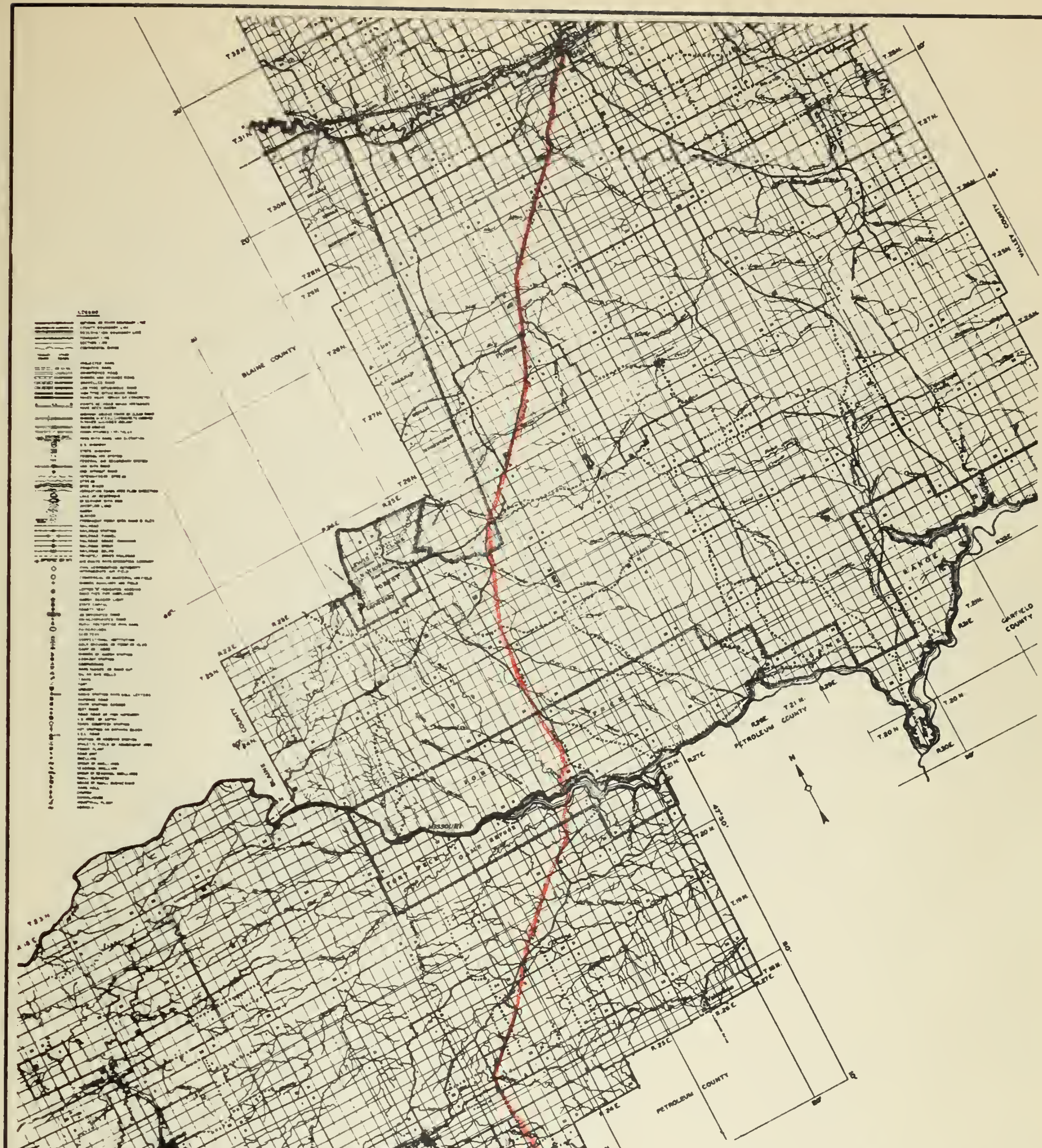

SKETCH OF GRASSRANGE-MALTA.
ROUTING, F.A. PRIMARY NO.16 PARTIAL
109.0 MILES

Montana State Highway Department
Traffic and Planning Section
Public Roads Administration
Basic Design Categories
Table No. 1

Standard	Average Daily Traffic	Classification	Max. Grade	Max. Curvature (Degree)	Sight Distance: Non Passing: Horiz. Curvature (Degree)	Sight Distance: Non Passing: Vertical Curvature (Algebraic Difference)	Sight Distance: Passing: Feet	Width of Road Bed at Grade	Shoulder Width	Width of Surfacing	Minimum Type of Surfacing	Minimum Base Course
0	0-200	20 M 40	7	14	14	SEE TABLE NO. 2.	280	24	3	800	18	Under 1" Oil	5"
1	201-400	50 M 40	7	14	14		290	28	4	800	20	2" Oil	6"
2	401-800	100 M 40	7	14	14		310	32	5	1100	22	2½" Oil	8"
3	801-1800	200 M 40	7	14	14		320	34	6	1100	22	2½" Oil	8"
4	1801-3500	300 M 40	7	14	14		330	38	8	1100	22	2½" Oil	8"
5	0-200	20 M 60	6	6	6		460	26	3	1700	20	Under 1" Oil	5"
6	201-400	50 M 60	6	6	6		460	30	4	1700	22	2" Oil	6"
7	401-800	100 M 60	6	6	6		470	32	5	2100	22	2½" Oil	8"
8	801-1800	200 M 60	6	6	6		480	34	6	2100	22	2½" Oil	8"
9	1801-3500	300 M 60	6	6	6		500	38	8	2100	22	2½" Oil	8"

Note: Roads having over 3500 vehicles per day require special design.

TABLE NO. 2

Table giving length of vertical curve required for various Non - passing sight distances

December 18, 1943

Algebraic Difference between grades for convex curvature.	Length of vertical curve for a Non-passing sight distance of: 280 feet	Length of vertical curve for a Non-passing sight distance of: 290 feet	Length of vertical curve for a Non-passing sight distance of: 310 feet	Length of vertical curve for a Non-passing sight distance of: 320 feet	Length of vertical curve for a Non-passing sight distance of: 330 feet	Length of vertical curve for a Non-passing sight distance of: 460 feet	Length of vertical curve for a Non-passing sight distance of: 470 feet	Length of vertical curve for a Non-passing sight distance of: 480 feet	Length of vertical curve for a Non-passing sight distance of: 500 feet
1.00	96	103	117	125	133	258	269	281	305
2.00	191	205	234	250	266	516	539	562	610
3.00	287	308	352	375	398	774	808	843	915
4.00	382	410	469	500	531	1032	1078	1124	1220
5.00	478	513	586	624	664	1290	1347	1405	1524
6.00	574	615	703	749	797	1548	1616	1686	1829
7.00	669	718	820	874	930	1806	1886	1967	2134
8.00	765	820	938	999	1062	2064	2155	2248	2439
9.00	860	923	1055	1124	1195	2322	2425	2529	2744
10.00	956	1026	1172	1249	1328	2581	2694	2810	3049
11.00	1052	1128	1289	1374	1461	2839	2963	3091	3354
12.00	1147	1231	1406	1499	1594	3097	3233	3372	3659
13.00	1243	1333	1524	1623	1726	3355	3502	3653	3963
14.00	1339	1436	1641	1748	1859	3613	3771	3934	4268

MONTANA HIGHWAY PLANNING SURVEY

GUIDES FOR ESTIMATING 1960 TRAFFIC

		Applies to:
1.	100% = 1941 traffic.	
2.	110% to 125% = Traffic if route is unimproved at present time but expected to be improved by 1960.	F.A., F.A.S. and Class 1, 2, & 3 Forest Highways. Applies to sparcely settled rural areas. (Add extra traffic generated by logging activities on timber utilization roads or other major industries and traffic induced by these activities).
3.	125% to 150% = Traffic if route is unimproved at present time but expected to be improved by 1960.	F.A., F.A.S. and Class 1, 2, & 3 Forest Highways. Applies in checkerboard well-settled rural areas or on through-roads. (Add extra traffic generated by logging activities on timber utilization roads or other major industries and traffic induced by these activities).
4.	150% to 200% = Traffic if route is unimproved at present time but expected to be improved by 1960.	F.A., F.A.S. and Class 1, 2, & 3 Forest Highways. This applies in exceptional cases such as bottlenecks and natural cutoffs. Some cases, of course, might be much more but these special conditions would require special analysis. (Add extra traffic generated by logging activities on timber utilization roads or other major industries and traffic induced by these activities).
Note:	Date of expected improvement does not change traffic estimates for 1960.	

130% = expected secular growth 1941 to 1960 -- to be applied to all above conditions except traffic generated by logging activities, or other major industries.

Applies to all roads now constructed. (Without any of above increases)

Average summer maximum traffic equals double average ADT except on predominately recreational routes where factor might be as high as 3.

Average summer maximum traffic equals average of several maximum summer days.

Maximum hour equals 10% of maximum summer ADT. (Usual public traffic), or 15 to 20% on roads used by both the public and by major logging operations or other major industries.

TABLE OF CONTENTS

ECONOMIC ANALYSIS OF THE MALTA-
GRASS RANGE SECTION OF FEDERAL
AID ROUTE NO. 16

I. SUMMARY OF FINDINGS

Herewith report as per title above using the principles of the Oregon "Solvency Quotient" method. By setting up a mathematical relationship between estimated costs on the one hand and possible future revenues and benefits on the other, one arrives at a quotient resultant, an index so to speak, to aid in programming funds for highway construction. All the factors involved in the derivation of solvency quotients grow out of or are influenced by the economy of the region touching on or adjoining the route under analysis. Any course of action recommended by the application of the solvency quotient method is, therefore, premised on a business-like procedure, and it follows, obviously, that such action will be in the greatest interest of the public. In this particular analysis, the economic analysis shows that the Grass Range-Malta routing is qualified for construction by a relatively high solvency quotient, 1.54.

II. ROUTE DESCRIPTIONS

The route being analyzed extends from Grass Range in Fergus County to Malta in Phillips County a total distance of 109 miles, it comprises the northerly section of the presently designated Federal Aid Primary Route No.16. Beginning near Grass Range the routing proceeds north to a junction with F. A. Route No. 16 near Roy -- via the present traveled way the distance is 26.6 miles, the route distance is 21.6 miles. From this point the routing goes northeasterly to the Missouri River, crossing at or near the present Wilder Ferry site where it leaves Fergus County. The first 5.7 miles of this interval, were graded and gravelled with Federal Aid in 1940; the last 18.0 miles are now tentatively programmed for grading only. The total route

distance in Fergus County is 46.3 miles. From the Wilder Ferry Site the routing bears north, - north-easterly via existing county roads to a point some three miles south of Phillips, a total designated route distance of 35.4 miles; the northerly 6 miles of the latter mentioned interval are tentatively programmed for grading, gravelling and oil surfacing. The routing from the point 3 miles south of Phillips to the junction with F.A. Route No.1 in Malta is oil surfaced having been improved with Federal Aid in the period 1938 - 1942. Total designated route distance in Phillips County, 62.7 miles. It is probable that construction costs on the approaches to the proposed Missouri River Bridge will be quite high because the routing traverses a considerable section of the "breaks" of the Missouri River. Costs for the bridge proper will, no doubt, be high also -- this crossing site is below the "head of navigation" as designated by the War Department hence the clearance will have to be in the neighborhood of 50 feet in respect to normal water elevation.

III. TRAFFIC DATA

Traffic and vocational pursuits are inter-related to a remarkable degree the area traversed by the routing being analyzed leans to a farm-grazing economy throughout. Generally speaking we cannot reasonably expect any great volume of local traffic on completion of the routing - the farms and ranches are too scattered, there is not a sufficient population to furnish or generate traffic, farm-grazing as an industry does not promote highway traffic. This is not to say that the region will be lacking in agricultural potentialities nor do we say that there will not be a significant growth in road use should the routing be completed at some time in the future. On reference to the "Traffic Estimation Guide", page iii, we find certain factors, empirical admittedly, which when applied to existing traffic volumes, give an estimated average daily traffic in 1960 of 49 vehicles per day per mile throughout the length of the

routing. Traffic of interest, that is, traffic in excess of 50 vehicle a day extends over two intervals of the road; Grass Range to the junction with the Lewistown - Roy road a distance of 21.6 miles and from Malta South through Phillips and through that section tentatively programmed in Phillips County, a distance of 33 miles. Over the first mentioned section and for the year 1960 it is estimated that there will be 52 local vehicles per day and over the second cited interval there will be 103 vehicles per day. On the remaining 54.4 miles, nearly half, the traffic will average 15 vehicles per day per mile.

Add to this an effective diversion of 91 vehicles per day to bring the total estimated traffic volume to 140 vehicles per day as of 1960. Data in reference to possible diversions derive from an Origin-destination study conducted in 1936 - 1937 at two study points, one near Malta and the other near Billings. Of the total diversions about 20% will have origin-destination in or near Lewistown and west or east of Malta on U.S. 2, the rest of the diversion will have origin-destination south of Grass Range on U.S. 87 and west or east of Malta on U.S. 2.

IV. ECONOMIC ANALYSIS

Now to determine the several variables which enter in the derivation of quotients to complete the economic analysis.

A. Annual Cost Calculations

The status of the Malta-Grass Range routing in respect to mileage completed, mileage tentatively programmed and mileage remaining to be constructed in addition to that tentatively programmed is as follows:

1. Completed work
   a. Graded, gravelled, oiled and drained, 78.0 miles.
   b. Graded, gravelled and drained, 6.0 miles.

2. Tentatively programmed

a. Grading, gravelling, oiling and installation of drainage structures, 6.0 miles.

b. Grading and installation of drainage structures, 18.0 miles.

c. Missouri River Bridge.

d. Under-pass at Malta.

3. Mileage Remaining in addition to that cited in sub paragraph, 2 above.

a. Grading, gravelling, oiling, and installation of drainage structures, 51.0 miles.

b. Gravelling and oiling, 18.0 miles.

c. Oiling, 6.0 miles.

Past construction "experience" in relation to costs of the completed work is as follows:

BASIC CONSTRUCTION COSTS
Malta - Grass Range

Project	Year	Miles	Grade	Bridges	Minor Dr.	Gravel	Oil	Constr. Engin.	Total
333 - B	1940	5.682	$38926		$9815	$30872		$5907	
	1940	0.036		$9548				699	
333 D(1) & (2)	1942	6.398	19591		9008	45458	9908	8097	
		0.049		15379				1116	
333 C(2)	1942	10.559	205			19655	16305	2394	
		0.095		28933				2325	
333 C(1)	1940	10.559	40830		18106	60063		9098	
		.095							
333 A(3)	1942	9.513	339			18509	15767	2291	
		0.093							
333 A (3)	1942	0.056	5			198	224	28	
333 A(1)	1942	0.377	3837		894	4602	1519	718	
333 A(2)	1940	0.227	955			275		82	
333 A	1938	9.513	45876		10070	29998		7742	
333 A(1)	1938	0.056	496		319	626		130	
MC 911	1932	1.000	500			3750	1650	620	
333 A(2)	1940	0.030		21229				1706	
333 A(1)	1938	0.089		22493				1693	
TOTALS		33.868	$151560	$97582	$48212	$214006	$45373	$44646	$601379
Average Cost Per Mi.		33.868	$4475	$2881	$1425	$6319		$1318	
Average Cost Per Mi.		28.186	$3996	$3123	$1362	$6497	$1610	$1374	

Funds tentatively allocated, and based on engineering estimates which comprehend actual construction costs, engineering, over-head, purchase of Right of Way, and contingencies, are as follows:

Grading, drainage structures,	18.0 miles @ $20,000	$360,000
Grading, gravelling, oil surfacing & Drainage structures	60 miles @ $28,333	170,000
Missouri River Bridge,		400,000
Malta Under-pass,		162,000
		1,092,000

Drawing on the "experience" data set forth immediately herebefore and allowing for a 25% increase in costs during the post-war period, we estimate average costs per mile for the remaining work to be as follows:

Grading, gravelling, oiling, installation of drainage structures, 51 miles.

Grading	$5,600
Gravel Base and Surface	7,900
Minor Drainage Structures	1,800
Major Structures (small bridges)	3,600
Oil Surfacing	2,000
Engineering and Administration	1,700
Right of Way	1,000
Sub total.....	$23,600
Plus 10% for Contingencies.....	2,360
Total estimated cost per mile, new constr.	$25,960

Gravelling and Oiling, 18.0 miles.

Gravel Base and Surface	7,900
Oil Surfacing	2,000
Engineering and Administration	800

Sub total.....	$10,700
Plus 10% for contingencies.....	1,070
Total estimated cost per mile, new construction.....	$11,770

Oil Surfacing

Oil surfacing	$2,000
Engineering and Administration	200
Sub total.....	$2,200
Plus 10% for contingencies.....	220
Total Estimated Cost per mile, new construction.....	$2,420

Construction

Summarizing, construction costs, past and probable future, we have results as follows:

Past construction costs	$601,379
Tentatively programmed	$1,092,000
Probable future	
Grading, gravelling, oiling, installation of drainage structures, 51 miles @ $25,960	$1,323,960
Gravelling and oiling, 18 miles @ $11,770	211,860
Oiling, 60 miles @ $2,420	14,520
Total estimated construction cost.....	$3,243,719

In consideration of possible increased construction costs at some time in the future when the road will require reconstruction, interest at the rate of 2½% will be applied to the principal set forth hereabove. Principal and interest in reference to the Missouri River Bridge and the Malta Under-pass costs will be retired in 40 years; other features of construction will be retired in 20 years. The annual capital cost for construction cost will be as follows:

Missouri River Bridge			
and Malta Underpass	$562,000 x 0.0398	=	$22,368
Other Construction	$2,681,719 x 0.0641	=	$171,898
Total Annual Capital Cost for construction		=	$194,266

From data at hand in reference to maintenance costs, it is estimated that an annual charge of $250 per mile will cover this item. The total annual capital cost as of 1960 is estimated to be $221,516. (194,266 / 27,250)

B. AVERAGE DAILY TRAFFIC, 1960

Traffic will comprise two categories, existing traffic and diverted traffic.

1. Existing traffic.

As of 1941 the average daily traffic was recorded at 25 vehicles per day per mile over the full length of the present travelled way, 130 miles. As a circumstance of completion of the routing and in consideration of normal growth it is estimated that this traffic will be 49 vehicles per day per mile in 1960. (See Guide to Traffic estimation page iii)

2. Diverted Traffic.

From data based on Origin-destination studies conducted in 1936-1937 at study points near Malta and Billings it is estimated that, as of 1941, 52 passengers cars will divert to the Grass Range - Malta routing. Trucks, busses, and trailers combination were added in the proportion in which this traffic bears to the whole of traffic at the study points to bring the total of the diverted traffic to 70 vehicles per day. This figure was increased to 91 vehicles per day to allow for normal traffic growth. (See Guide to Traffic Estimation, page iii)

3. All Traffic, 1960

The tabulation which follows presents estimated traffic along with route data, "old" and "new".

ESTIMATED TRAFFIC MALTA - GRASS RANGE

1960

Average Daily Traffic

Vehicle Type	Route data (miles) old distance	new distance	1941	50% on comp. const.	30% 1960
Existing Traffic	130	109			
Passenger cars, local			15.5	23.3	30.3
Passenger cars, Foreign			0.3	0.4	0.7
Passenger cars, All			15.8	23.7	31.0
Light Trucks			7.6	11.4	14.8
Medium Trucks			0.4	0.6	0.8
Heavy Trucks			0.1	0.2	0.2
Trac. Tk. & Semi Trailers			0.4	0.6	0.8
Trucks & Full Trailers			0.3	0.4	0.6
Busses			0.4	0.6	0.8
All trucks & Busses			9.2	13.8	18.0
All Traffic			25.0	37.5	49.0
Diverted Traffic	Variable	109			
Passenger Cars, local			41		54
Passenger Cars, Foreign			11		14
Passenger Cars, All			52		68
Light Trucks			11.9		15.2
Medium Trucks			0.7		0.9
Heavy Trucks			0.1		0.1
Trac. Tks. - Semi-trlrs.			3.1		3.9
Trucks & Full Trailers			1.6		2.1
Busses			0.6		0.8
All Trucks & Busses			18.0		23.0
All traffic			70.0		91.0

C. ANNUAL REVENUES

To arrive at an estimate of annual revenues, the traffic data were resolved in vehicle miles and then into ton miles. These data were extended on the basis of unit net revenues per ton mile to arrive at an estimate of the total annual revenue. Unit net revenue rates derive from a general study conducted by this department. Average gross ton figures for each class of vehicle were ascertained in the course of research work by the Planning Survey.

HIGHWAY PROJECT ANALYSIS — Traffic Income

Location of project Montana — Description of project Grass Range-Malta — County Fergus & Phillips
Highway FA No. 16, Partial — Highway System FA Primary — Length 109.0 miles — Date of analysis February 1946

Traffic Type	Average Annual Traffic: Existing Traffic: Vehicles	Existing Traffic: Tons	Diverted Traffic: Vehicles	Diverted Traffic: Tons	Average Annual Road Use During Life of Project: Ton Mile	Unit Net Revenues Per Ton Mile	Total Annual Net Revenue
Passenger Cars - Montana	11,060	16,590	19,710	29,565	5,030,895	0.002,188	$7,598
Passenger Cars - Foreign	256	384	5,110	7,665	877,341	0.001,779	1,561
Total passenger cars	11,316	16,974	24,820	37,230	5,908,236		$ 9,159
Trucks, light	5,402	17,665	5,548	18,142	3,902,963	0.003,248	12,677
Trucks, medium	292	2,009	329	2,264	465,757	0.002,382	1,109
Trucks, heavy	73	814	36	401	132,435	0.001,619	214
Trucks, semi-trailer	292	4,310	1,423	21,003	2,759,117	0.001,543	4,257
Trucks, full-trailer	219	5,013	767	17,557	2,460,130	0.001,396	3,434
Busses,	292	2,628	292	2,628	572,904	0.001,873	1,073
Total trucks & busses	6,570	32,439	8,395	61,995	10,293,306		$22,764
Total all vehicles	17,886	49,413	33,215	99,225	16,201,542		$35,441

Average weight of trucks 6.31 tons; All vehicles 2.91 tons. Total Annual Income..... $ 35,441

Percentage truck traffic 29.3%.

Amortization period 20 years and 40 years.

D. TIME ELEMENT SAVINGS

Time Element Savings accrue to traffic as a result of surface and alignment improvements and because of shortened travel distance. In this particular instance the "Existing Traffic" will be benefited by a decrease in travel distance of 21 miles and an improvement in surface type and alignment to allow an accelerated speed throughout the length of the improvement. The "Diverted Traffic" will be benefited by a composite travel distance decrease each trip of 165 miles to effect a great time saving--diverted traffic will not be materially benefited by surface type or alignment improvement. The tabulation follows hereinafter.

Time Element Savings

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Fergus & Phillips
Description of project Grass Range-Malta
Highway number FA No. 15 Partial Highway system FA Primary
Length 109.0 Miles Date of analysis February 1946

	Existing Traffic Routes		Diverted Traffic	
Annual Traffic Volume	New	Old	New	Old
Private Passenger cars (per Year)	11,316		24,820	
Trucks, light (per year)	5,402		5,548	
Trucks, medium (per year)	292		329	
1/ Trucks, heavy (per year)	876		2,518	
Totals	17,886		33,215	
Private Passenger Cars				
Average speed (miles per hour)	43	35	43	43
Distance (miles)	109	130	144	309
Time (hours per trip)	2.535	3.714	3.349	7.186
Time savings per vehicle	1.179		3.837	
Value of savings ($/vehicle-hour)	$0.60		$0.60	
Annual traffic volume	11,316		24,820	
Totals	$ 8,005		$ 57,141	
Trucks, light				
Average speed (miles per hour)	39	31	39	39
Distance (miles)	109	130	144	309
Time (hours per trip)	2.795	4.194	3.692	7.923
Time savings per vehicle	1.399		4.231	
Value of savings ($/vehicle-hour)	$0.86		$0.86	
Annual traffic volume	5,402		5,548	
Totals	$ 6,499		$20,187	

Time Element Savings (cont'd)

Trucks, Medium				
Average speed (miles per hour)...	35	27	35	35
Distance (miles).....	109	130	144	309
Time (hours per trip).....	3.114	4.815	4.114	8.829
Time savings per vehicle.....	1.701		4.715	
Value of savings ($/vehicle-hour)	$1.17		$1.17	
Annual traffic volume.....	292		329	
Totals.....	$ 581		$1,815	
Trucks, Heavy				
Average speed (miles per hour)...	32	24	32	32
Distance (miles).....	109	130	144	309
Time (hours per trip).....	3.406	5.417	4.500	9.656
Time savings per vehicle.....	2.011		5.156	
Value of savings ($/vehicle-hour)	$1.47		$1.47	
Annual traffic volume.....	876		2,518	
Totals.....	$2,590		$19,085	
Total each category.....	$17,675		$98,228	
TOTAL ANNUAL TIME ELEMENT SAVINGS.....			$115,903	

E. MILEAGE ELEMENT SAVINGS

These savings accrue to traffic considered in this analysis as a circumstance of improved surface type, improved alignment, and shortened travel distance. These improvements operate to decrease wear and tear on engines and tires; they make a gallon of gas stretch farther -- they are automotive functions and are of prime interest to the Highway Department because they are directly related to system condition. The savings are listed as follows:

Mileage Element Savings

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Fergus-Phillips
Description of Project Malta - Grass Range
Highway number FA No. 16, Partial Highway System FA Primary
Length 109.0 miles Date of Analysis February 1946

	Existing Traffic Routes		Diverted Traffic	
Distance	New	Old	New	Old
Length (miles)....1/.....	130	109	144	309
Distance saving (miles).....	21		165	
Average annual traffic (tons)....	49,413		99,225	
Annual traffic saving (ton-mi.)..	1,037,673		16,372,125	
Cost ($/ton-mile).....	$0.0188		$0.0188	
Totals.....	$19,508		$307,796	

Mileage Element Savings (cont'd)

Surface 2/	New	Old	New	Old
Roadway surface type.....	0.03	0.28		
Saving coefficient.....	0.25			
Aver. annual traffic (ton-mi.)...	6,423,690			
Saving($/ton-mile).....	$0.0047			
Total.....	$ 30,191			
Alignment 3/				
Curvature rating.....	10	0		
Points improvement.....	10			
Saving (point-ton-miles).....	64,236,900			
Saving ($/point-ton-mile).....	0.0001			
Total.....	$6424			
Total.....	$56,123		$307,796	
TOTAL ANNUAL MILEAGE ELEMENT SAVINGS.....		$363,919		

1/ In accord with procedures advanced by the Oregon Highway Department, Cost ($/ton-mile) are determined as follows:

Existing Traffic

Percentage of truck traffic, $\frac{6570}{17886} = 36.7\%$

Average gross weight trucks, $\frac{32,439}{6,570} = 4.937$ tons $= 9874$ lbs.

From Technical Bulletin No. 7, Oregon Highway Department, Fig. 113, find operating cost truck, average gross weight 9,874 lbs. to be $0.0155 per ton mile. The operating cost of passenger cars, as set forth in the bulletin is set at $0.0207 per ton mile. Combining these costs in the proportions manifest in this particular distribution of traffic we have results as follows:

Trucks, (36.7%) 0.367 x $0.0155 = $0.0057

Passenger Cars, (63.3%) 0.633 x 0.0207 = 0.0131

Combined operating cost per ton mile all traffic = $0.0188

Diverted Traffic

Percentage trucks = $\frac{8,395}{33,215} = 25.3\%$

Average gross weight trucks = $\frac{61,995}{8395} = 7.385$ tons $= 14,770$ lbs.

Operating cost per ton mile trucks in the above weight class is $0.0130

Combining in the proportions manifest in this distribution of traffic we have results as follows:

Passenger Cars, (74.7%)	0.747 x $0.0207	=	$0.0155
Trucks, (25.3%)	0.253 x $0.0130	=	$0.0033
Combined operating cost per ton mile		=	$0.0188

2/ Existing Traffic

In view of the fact that we have included those monies expended in 1938 -1942 in the calculation of the annual capital cost we will start from "scratch" in reference to the surface status of the existing road -- the coefficient is then adjudged to be 0.28 in line with procedures advanced by the Technical Bulletin. On completion of the routing the improvement coefficient will be 0.03 and the difference between these coefficients represents the "Savings coefficient." This savings coefficient, when applied to the previously determined operating cost, $0.0188 represents the savings in dollars per ton mile.

Diverted Traffic

That traffic which will be diverted to the new routing will not be benefited by an improvement in surface type -- for all practical purposes the present travelled way is deemed to be equal to the proposed routing insofar as surface type is concerned.

3/ Existing Traffic

The routing, as it existed prior to any improvement is deemed to be entirely lacking in alignment features, zero as set forth in the tabulation. On completion of the routing and in line with the dictates of standard requirements it is adjudged that the routing will have an alignment rating of

10. The difference between these ratings represents the "Points Improvement." Saving ($/point-ton mile) derives from the findings set forth in the Oregon Technical Bulletin.

Diverted Traffic

No improvement insofar as alignment features are concerned.

F. TRAFFIC BENEFITS

This tabulation involves an allocation of benefits to non-fuel functions and fuel functions in accord with the proportions advanced by the Oregon Highway Department.

Traffic Benefits

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Fergus - Phillips
Description of project Grass Range - Malta
Highway number FA No. 16, Partial Highway system FA Primary
Length 109.0 Miles Date of analysis February 1946

Mileage Element Factors

Item			Fuel Function	Non-fuel Function
Distance savings	$327,304	38%	$ 124,376	$ 202,928
Roadway surface savings	30,191	41%	12,378	17,813
Alignment savings	6,424	50%	3,212	3,212
Total Mileage Savings	$363,919		$ 139,966	$ 223,953

Time Element Factors

Type of Traffic	Annual Value of Time Savings
Passenger cars	$ 65,146
Trucks, light	26,686
Trucks, medium	2,396
Trucks, heavy	21,675
Total Time Savings	$115,903

Recapitulation of Annual Benefits

Total Fuel Function Benefits		$139,966
Non-fuel function benefits (Mileage element factors	$223,953	
(Time element factors	$115,903	
Total Non-fuel Function Benefits		$339,856
TOTAL ANNUAL BENEFITS		$479,882

G. DERIVATION OF QUOTIENTS

With such factual data as we have assembled heretofore in reference to cost, income and benefits we are now enabled to draw out certain conclusions in reference to the economic solvency of the proposed routing.

HIGHWAY PROJECT ANALYSIS

Location of project Montana County Fergus - Phillips
Description of project Grass Range - Malta
Highway number FA No. 16 Highway system FA Primary
Length 109.0 Miles Date of analysis February 1946

Iar = $ 35,441 1/ K_1 = 1.00

Ca = $ 221,516 2/ K_2 = 716,963/139,966 = 0.84

Bn = $ 339,856 3/ K_3 = 0.05/0.70 = 0.25

Bf = $ 139,966 4/ K_2K_3 = 0.25 x 0.84 = 0.21

5/ K_1C_a = $ 221,516 $1-K_2K_3$ = 0.79

6/ $Q_s = Iar/K_1C_a$ = 35,441/221,516 = 0.16

7/ $Q_{Bn} = B_n/K_1C_a$ = 339,856/221,516 = 1.53

8/ $Q_{Bf} = B_f/K_1C_a$ = 139,966/221,516 = 0.63

9/ $Q'_s = Q_s - K_2K_3Q_{Bf}$ = 0.16 - 0.21 x 0.63 = 0.16 - 0.13 = 0.03

10/ $Q_c = 0.707 (Q_s / Q_{Bn} / Q_{Bf} (1-K_2K_3)$ = 0.707 (0.16 / 1.53 / 0.63 x 0.79)

= 0.707 (0.16 / 1.53 / 0.50)

= 0.707 x 2.19

= 1.55

1/ The constant K_1 represents the pro rata cost chargeable to Road User Funds.

2/ The constant K_2 represents the proportion of the total fuel savings which derives from use of the proposed improvement by diverted traffic. By reference to the tabulation of Mileage Element Savings we find that the fuel function benefits accruing to the diverted traffic are as follows:

Distance Savings, 38 of $307,796 = $116,963

Dividing this value by the total value of the fuel savings as listed on the tabulation of "Traffic Benefits," we arrive at the constant value of K_2, 0.84.

3/ The constant K_3 represents the ratio of the fuel tax to the total cost of fuel.

4/ By applying the constant value K_2 to the constant value K_3 we arrive at a resultant indicative of the decrease in revenues occasioned by construction of the proposed routing.

5/ Application of the constant K_1 to the calculated annual capital cost indicates that the total annual capital costs are to be paid out of road user funds.

6/ The quotient Q_S, 0.16 in this case indicates that the route, when built, will earn 16% of its cost.

7/ and 8/ The quotient Q_{B_N} and Q_{B_F}, representing non-fuel benefits and fuel benefits respectively, show that the monetary values of these benefits will exceed the capital costs by 53% in the first case and will equal almost two-thirds of the capital costs in the second instance.

9/ Q'_S represents a corrected solvency quotient. The immediate effect of diverting traffic to the routing will be to decrease revenues on the Lewistown - Great Falls, Havre - Malta highways -- this quotient represents the relative solvency standing of the routing as it would be if we were to "keep books" on all the roads in the region which are involved in the diversion.

10/ Q_C represents the composite quotient of the routing when income and benefits in relation to costs are taken into consideration, -- it is the true measure of the economic worth of any proposed routing. This statement is conditioned on "necessity" of other elements of the highway system -- if, for

example, other parts of the highway system in the area are deficient by reason of wear and tear, inadequate surface width, short sight distances, poor alignment and other road features relating to mileage element or truly functional use, then these deficient intervals would govern in the allocation of funds in any program of highway improvement. However the composite quotient in this instance is sufficiently high to render it on a par, figuratively speaking, with other improvement proposals in the area. It is feasible but not truly necessary to build a road or routing when the composite quotient is unity, this -- generally speaking, is indicative of a situation whereby benefits would equal anticipated revenue. In other words, the benefits would operate to pay revenues, in which case the existing roads would serve adequately. The composite quotient in this particular analysis is 1.55, a resultant which, from an economic standpoint would recommend the improvement of the route as a whole. As a point of interest, if we extract the time element savings in the computation of the composite quotient we have a resultant quotient, 1.18, which shows the economic feasibility of building the routing on the basis of mileage element or functional savings alone.

V. RECOMMENDATIONS

Pending completion of deficiency studies on all roads which are involved in the problem posed by the necessity for additional Missouri River Crossings, it is recommended that the Phillips County road work as presently programmed be carried on and that the programmed road work in Fergus County be deferred. By so constructing along the route as proposed the Highway Commission will have served to the outer limits of the existing "traffic of interest" while awaiting a decision in reference to the "necessity" of other highway sections in the area.